**242A-WP-8-01**
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**RTCA SC- 186/WG-6 (Working Group On DO-242A MASPS)**

**Meeting #8, Washington DC**

# Draft Text for DO-242A

## Revised SV, MS, and OC Report Contents

**Presented by James Maynard**

| SUMMARY |
|---|
| This paper offers draft text for DO-242A in support of several action items. Included also are revisions to reflect contributions from other authors presented at WG-6 meeting #7, held 2001 August 27-30 at the RTCA and GAMA offices in Washington, DC.<br>[The text is color-coded: black for original text from DO-242, blue for changes to that text.]<br>The changes from the previous draft are listed on the following page. |

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| In accordance with discussions at meeting #7:<br>• The list of participant categories in Section 2.2.1.3 was changed from a numbered list to a bulleted list.<br>• New categories (“small” and “large” aircraft, “point obstacle,” “cluster obstacle,” and “line obstacle”) were added.<br>• “Point obstacle” was described as “(includes tethered balloons).”<br>• Notes 1 and 2 were added after the list of participant categories. |
| Also in section 2.2.1.2, I added a Note 3 to indicate that the Participant Category is included in the MS report. |
| The Altitude Rate description, section 2.1.2.2.2.2, was modified to reflect changes agreed to when WG-6 discussed Jonathan Hammer’s paper #242A-WP-7-11. |
| The wording of Note 3 for Table 2.1.2.3.2.1 was modified in accordance with a suggestion from Gary Livack. |
| The descriptions of fields in the OC-TSR (Target State Report) incorporate and elaborate wording from working paper #242A-WP-7-03, which Tony Warren presented at meeting #7. |
| I added text (section 2.1.2.1.4) describing the new Aircraft Size code Since Aircraft Size Code is similar in a way to Aircraft Category, I classified it as one of the “Identity” report elements (like Address, Address Qualifier, and Participant Category) and included it in the MS report (section 3.4.3.2). This was a somewhat arbitrary decision: it might have gone in either the MS report or in an OC report.<br>• On the one hand, the aircraft’s size code is static, unchanging information -- which argues for classifying it as an element of the MS report, like the participant category code.<br>• On the other hand, messages sent to convey the aircraft size code need only be sent under certain conditions: for aircraft of a certain size, when those aircraft are on the ground -- which argues for calling it an OC report. |
| I added text describing possible future OC-AILS and OC-RFI report formats. This text properly belongs in Appendix M, but I include it here for the purpose of provoking a discussion in Meeting #8. |
| I have incorporated the changes to Tables 3-1, 3-3(a), 3-3(b), and 3-4, and Section 3.2.3.1, that were proposed by Jonathan Hammer in Issue Paper #46. |

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# 1 Purpose and Scope

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## 2.1 General Requirements

### 2.1.1 General Performance

#### 2.1.1.1 Consistent Quantization of Data

When the full resolution of available aircraft data cannot be accommodated within an ADS-B message, a common quantization algorithm shall (R2.1) be used to ensure consistent performance across different implementations. To minimize uncertainty, a standard algorithm for rounding/truncation is required for all parameters. For example, if one system rounds altitude to the nearest 100 feet and another truncates, the same measured altitude could be reported as different values.

#### 2.1.1.2 ADS-B Report Characteristics

The output of ADS-B shall (R2.2) be standardized so that it can be translated without compromising accuracy. The ADS-B reports should support surface and airborne applications anywhere around the globe and should support chock-to-chock operations without the need for pilot adjustments or calibration.

#### 2.1.1.3 Expandability

Applications envisioned for using the information provided by ADS-B are not fully developed. In addition, the potential for future applications to need information from an ADS-B is considered fairly high. Therefore the ADS-B system defined to meet the requirement in this MASPS needs to be flexible and expandable. Any broadcast technique should have excess capacity to accommodate increases and changes in message structure, message length, message type and update rates.

<u>Note</u>:*The update rate is the effective received update rate as measured at the receiving end system application (e.g., the automation system interface by ADS ground processing), not the transmission rate of the ADS-B system.*

This MASPS identifies different report parameters with different update rates. In some cases the resolution of the parameters may be different depending on the intended use. Ideally, the system should be designed so that message types, message structures, and report update rates can be changed and adapted by system upgrades.

#### 2.1.1.4 Time of Applicability

The time of applicability of ADS-B reports indicates the time at which the reported values were valid. Time of applicability shall (R2.3) be provided in all reports. Requirements on the accuracy of the time of applicability are addressed in Section 3.

### 2.1.2 Information Transfer Requirements

The ADS-B system shall (R2.4) be capable of transmitting messages containing the information specified in the following subsections. This MASPS does not specify a particular message structure or encoding technique. The information specified in the following subsections can be sent in one or more messages in order to meet the report update requirements specified in Section 3.

#### 2.1.2.1 Identification

The basic identification information to be conveyed by ADS-B shall (R2.5) include the following elements:

- Call sign
- Address
- Category
- Aircraft Size Code

The ADS-B system design shall (R2.6) accommodate a means to ensure anonymity whenever pilots elect to operate under flight rules permitting an anonymous mode. (Most on-IFR flight operations do not require one to fully disclose either the A/V call sign or address. This feature is provided to encourage voluntary equipage and operation of ADS-B by ensuring that ADS-B messages will not be traceable to an aircraft if the operator requires anonymity.)

##### 2.1.2.1.1 Call Sign

ADS-B shall (R2.7) be able to convey an aircraft call sign of up to 7 alphanumeric characters in length [6]. For aircraft/vehicles not receiving ATS services and military aircraft the call sign is not required.

##### 2.1.2.1.2 Address and Address Qualifier

The ADS-B system design shall (R2.8) include a means (e.g., an address) to 1, correlate all ADS-B messages transmitted from the A/V and 2, differentiate it from other A/Vs in the operational domain.

Those aircraft requesting ATC services will be required in some jurisdictions to use the same 24 bit address for all CNS systems. Aircraft with Mode-S transponders using an ICAO 24 bit address shall (R2.9) use the same 24 bit address for ADS-B. All aircraft/vehicle addresses shall (R2.10) be unique within the operational domain(s) applicable.

Associated with the address there shall (R2.xx) be an address qualifier code to indicate whether the address is an ICAP 24-bit aircraft address or some other kind of address.

*<u>Notes</u>:*

1. *For example, all surface vehicles for a given airport need to have unique addresses only within range of the airport; vehicle addresses may be reused at other airports.*
2. *Correlation of ADS-B messages with transponder codes will facilitate the integration of radar and ADS-B information on the same A/V during transition.*
3. *A participant's address and address qualifier are included as parts of <u>all</u> reports about that participant: State Vector (SV) reports, Mode Status (MS) reports, and the various types of On Condition (OC) reports.*

#### 2.1.2.1.2.1 Participant Address

The Participant Address field is a required field in all ADS-B reports. This 24-bit field contains either the ICAO 24-bit address assigned to the particular aircraft about which the report is concerned, or another kind of address, as determined by the Address Qualifier field.

#### 2.1.2.1.2.2 Address Qualifier

The Address Qualifier field is a required field in all ADS-B reports. This field consists of one or more bits and describes whether or not the Address field contains the 24-bit ICAO address of a particular aircraft, or another kind of address. The number of bits in the Address Qualifier field and the encoding of those bits are expected to be defined in lower-level documents, such as the MOPS (Minimum Operational Performance Specification) for a particular data link.

*<u>Note</u>: The particular encoding used for the Address Qualifier is not specified in this MASPS, but is left for specification in lower level documents, such as the MOPS for a particular ADS-B data link. Experience in developing the MOPS for several proposed ADS-B data links suggests that 4 bits is sufficient for the Address Qualifier field.*

#### 2.1.2.1.3 Participant Category

Participant category (Aircraft/vehicle category) shall (R2.11) be one of the following:

- Light aircraft (ICAO) - 7,000 kg (15,500 lbs) or less
- Small aircraft – 7,000 kg to 34,000 kg (15,500 lbs to 75,000 lbs)
- Large aircraft – 34,000 kg to 136,000 kg (75,000 lbs to 300,00 lbs)
- High vortex large (aircraft such as B-757)
- Heavy aircraft (ICAO) - 136,000 kg (300,000 lbs) or more
- Highly maneuverable ( > 5g acceleration capability) and high speed (> 400 knots cruise)
- Rotorcraft
- Glider/Sailplane
- Lighter-than-air
- Unmanned Aerial vehicle
- Space/Transatmospheric vehicle
- Ultralight / Hang glider / Paraglider
- Parachutist/Skydiver
- Surface Vehicle - emergency vehicle
- Surface Vehicle - service vehicle
- Point obstacle (includes tethered balloons)
- Cluster obstacle
- Line obstacle

*Note 1*: *ICAO Medium aircraft – 7,000 to 136,000 kg (15,500 to 300,000 lbs) can be represented as either small or large aircraft as defined above.*

*Note 2*: *Obstacles can be either fixed or movable. Movable obstacles would require a position source.*

*Note 3*: *A participant's category is reported in the Mode Status (MS) report (section 3.4.3.2 below).*

### 2.1.2.1.4 Aircraft Size Code

The aircraft size code describes the amount of space that an aircraft occupies. The aircraft size code is not required to be transmitted by all ADS-B participants all of the time. However, it *is* required to be transmitted by aircraft above a certain size, at least while those aircraft are in the airport surface movement area.

The aircraft size code shall (R2.xx) be as described in Table 2.1.2.1.4. The aircraft size code is a four-bit code, in which the 3 most significant bits (the length code) classify the aircraft into one of eight length categories, and the least significant bit (the width code) classifies the aircraft into a "narrow" or "wide" subcategory.

Each aircraft shall (R2.xx) be assigned the smallest length and width codes for which its overall length and wingspan qualify it. For example, consider a powered glider with overall length of 25 m and wingspan of 50 m. Normally, an aircraft of that length would be in length category 0. But since the wingspan exceeds 33 m, it will not fit within even the "wide" subcategory of length category 0. Such an aircraft would be assigned length category 3 and width category 1, meaning "length less than 54 m and wingspan less than 52 m."

Each aircraft ADS-B participant for which the length code is 3 or more (length greater than 39 m or wingspan greater than 48 m) shall (R2.xx) transmit its aircraft size code while it is on the surface.

**Table 2.1.2.1.4: Aircraft Size Codes.**

| **Length Code (3 MSBs)** | | | **Width (Wingspan) Code (LSB)** | |
|---|---|---|---|---|
| **dec.** | **binary** | **Length Category** | **Narrow** (LSB = 0) | **Wide** (LSB = 1) |
| 0 | 0 0 0 | L < 30 m | W < 16.5 m | 16.5 m ≤ W < 33 m |
| 1 | 0 0 1 | L < 38 m | W < 30.5 m | 30.5 m ≤ W < 38 m |
| 2 | 0 1 0 | L < 46 m | W < 38 m | 38 m ≤ W < 48 m |
| 3 | 0 1 1 | L < 54 m | W < 42 m | 42 m ≤ W < 52 m |
| 4 | 1 0 0 | L < 62 m | W < 51.5 m | 51.5 m ≤ W < 65 m |
| 5 | 1 0 1 | L < 70 m | W < 66.5 m | 66.5 m ≤ W < 74 m |
| 6 | 1 1 0 | L < 78 m | W < 69.5 m | 69.5 m ≤ W < 80 m |
| 7 | 1 1 1 | L ≥ 78 m | W < 84 m | W ≥ 84 m |

The aircraft size code is reported in the MS (Mode Status) report (section 3.4.3.2).

### 2.1.2.2 State Vector

The reported state vector for an A/V includes the three-dimensional position and velocity referenced to an accepted world-wide reference system.

The accuracy of the state vector information affects its utility for surveillance applications. Accuracy requirements for surveillance applications using ADS-B are based on the uncertainty in each state vector element that is required to support a given application.

*Note: The accuracy and integrity of the position and velocity elements of the state vector are communicated in the Mode Status report. See the descriptions of Navigation Integrity Category (NIC), Navigation Accuracy Categories for Position and Velocity ($NAC_P$ and $NAC_V$), and Surveillance Integrity Level (SIL) in subsections 2.1.2.3.2.1 to 2.1.2.3.2.4 below.*

Factors that affect state vector accuracy include:

- Errors in the navigational sensor system. For applications using ADS-B data, the measuring system is the aircraft/vehicle's navigation system. The error in the measured state vector will vary widely depending on the navigation source or sources used.
- Errors in the ADS-B reporting system. Additional error may be added due to the resolution of the reported state vector element (that is, the minimum increment that can be reported).
- Errors in the time of applicability. Because the A/V is moving, the reported state vector needs to meet latency requirements.
- Errors introduced by processing. Errors may also be introduced through the processing of the state vector data. These may be introduced, for example, from coordinate conversions and round-off errors in representing position and time values.

Aircraft/vehicle state vector information shall (R2.12) include the following elements:

- Three-dimensional position
- Three-dimensional velocity
- Time of applicability of the three-dimensional position and velocity.

All non-stationary ADS-B subsystem installations shall (R2.13) provide dynamic state vector reporting.

#### 2.1.2.2.1 Position

Position information shall (R2.14) be transmitted in a form that can be translated, without loss of accuracy and integrity, to latitude, longitude, and barometric altitude and geometric height.

All geometric position elements shall (R2.15) be referenced to the WGS-84 ellipsoid.

##### 2.1.2.2.1.1 Horizontal Position

Horizontal latitude and longitude position shall (R2.16) be reported as a geometric position.

#### 2.1.2.2.1.2 Altitude

Both barometric pressure altitude and geometric altitude (height above the WGS-84 ellipsoid) shall (R2.17) be reported, if available. Some applications may have to compensate if only one source is available. However, when an A/V is operating on the airport surface, the altitude is not required to be reported, provided that the A/V indicates that it is on the surface.

##### 2.1.2.2.1.2.1 Pressure Altitude

Barometric pressure altitude is the reference for vertical separation within the NAS and ICAO airspace. Barometric pressure altitude shall (R2.18) be reported referenced to standard temperature and pressure.

##### 2.1.2.2.1.2.2 Geometric Altitude

Geometric altitude is defined as the shortest distance from the current aircraft position to the surface of the WGS-84 ellipsoid. It is positive for positions above the WGS-84 ellipsoid surface, and negative for positions below that surface.

##### 2.1.2.2.1.2.3 Altitude Range

Altitude shall (R2.19) be provided with a range from -1,000 ft up to +100,000 ft. For fixed or movable obstacles, the altitude of the highest point should be reported.

Note: *In this context, a "movable obstacle" means an obstacle that can change its position, but only very slowly, so that its horizontal velocity may be ignored.*

#### 2.1.2.2.2 Velocity Vector

Transmitting A/Vs that are not fixed or movable obstacles shall (R2.20) provide the following information:

- Horizontal Velocity Vector

Note: *In this context, a "movable obstacle" means an obstacle that can change its position, but only very slowly, so that its horizontal velocity may be ignored.*

In addition, transmitting A/Vs that are not fixed or movable obstacles and that are not known to be on the airport surface shall (R2.xx) provide the following information:

- Vertical Rate

ADS-B geometric velocity information shall (R2.21) be referenced to WGS-84 [7].

##### 2.1.2.2.2.1 Horizontal Velocity Vector

Horizontal velocity information shall (R2.xx) be transmitted in a form that can be translated, without loss of accuracy and integrity, to north-south and east-west velocity relative to the WGS-84 earth ellipsoid. Reported ranges shall (R2.22) be [0-250] knots on the surface and [0-4000] knots airborne.

###### 2.1.2.2.2.2 Altitude Rate

Altitude Rate shall (R2.23) be designated as climbing or descending and shall be reported up to 32,000 feet per minute (fpm). Barometric altitude rate is defined as the current rate of change of barometric altitude. Likewise, geometric altitude rate is the rate of change of geometric altitude.

The best available source of altitude rate information should be used to derive an altitude rate for broadcast. If differentially corrected GPS (WAAS, LAAS, or other) is available, geometric altitude rate as derived from the GPS source should be transmitted. If differentially corrected GPS is not available, but inertial augmented barometric altitude rate is available, inertial augmented barometric altitude rate will be the preferred source of altitude rate information. In the absence of GPS or inertial augmented barometric altitude rate, barometric altitude rate may be transmitted. A recommended Kalman filtering algorithm for deriving barometric altitude rate is provided in Appendix ??. Alternative algorithms or direct measurement sources may be used to derive barometric altitude rate if it is demonstrated that the performance of the alternative is at least as good as that of the algorithm described in Appendix ??.

##### 2.1.2.2.3 Heading

Heading indicates the orientation of the A/V, that is, the direction in which the nose of the aircraft is pointing. Heading is described as an angle measured clockwise from true north or magnetic north. The heading reference direction (true north or magnetic north) is conveyed in the MS report. If the heading of an A/V is available to the ADS-B transmitting subsystem on that A/V, then heading shall (R2.xx) be transmitted while that A/V is on the surface.

To promote ADS-B equipage by as many aircraft as possible, participants are not required to have a heading source available if their length code (part of the aircraft size code, section 2.1.2.1.4) is 2 or less. However, ADS-B participants of length code 3 or above shall (R2.xx) have a heading source available and shall (R2.xx) transmit messages to support the heading element of the SV report when those participants are on the surface.

Heading occurs not only in the SV report for participants on the airport surface, but also in the On Condition – Air Referenced Velocity (OC-ARV) report for airborne participants. If a transmitting ADS-B participant transmits messages to support OC-ARV reports, it shall (R2.xx) provide heading in those messages.

#### 2.1.2.3 Status Information

Status information is used to support ATS and A/V to A/V applications. Elements include:

- Capability Class (CC) Codes – used to indicate the capabilities of a transmitting ADS-B participant
- Operational Mode (OM) Parameter Codes – used to indicate which operational mode specific parameters are currently being sent by a transmitting ADS-B participant. (The parameters indicated by the Operational Mode Parameter Codes are delivered to client applications in various On Condition reports.)
- State Vector Integrity and Accuracy Codes
- Emergency/Priority Status (to support ATS applications)

### 2.1.2.3.1 Capability Class (CC) Codes

Capability class codes are used to indicate the capability of a participant to support engagement in specific operations. Known specific capability class codes are listed below. However, this is not an exhaustive set and provision should be made for future expansion of available class codes, including appropriate combinations thereof:

- CDTI based traffic display capability
- TCAS/ACAS installed and operational
- Service Level of the transmitting A/V
- Capability of transmitting Air Referenced Velocity
- Capability of transmitting Target Altitude
- Capability of transmitting Target Heading or Target Track Angle
- Capability of transmitting information to support Trajectory Change Reports for TCP, TCP+1, TCP+2, and TCP+3.
- Other capabilities, to be defined in later versions of this MASPS
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### 2.1.2.3.2 State Vector Integrity and Accuracy

The integrity and accuracy of the state vector navigation variables are characterized by Navigation Integrity Category (NIC), Navigation Accuracy Categories ($NAC_P$ and $NAC_V$), and Surveillance Integrity Level (SIL).

#### 2.1.2.3.2.1 Navigation Integrity Category

The Navigation Integrity Category (NIC) is reported so that surveillance applications may determine whether the reported position has an acceptable level of integrity for the intended use. The NIC parameter described in this subsection is intimately associated with the SIL (Surveillance Integrity Level) parameter described in subsection 2.1.2.3.2.4 below. The value of the NIC parameter specifies an integrity containment radius, $R_C$. The value of the SIL parameter specifies the probability of the true position lying outside the containment radius, $R_C$, without the possibility of its lying outside that radius being detected at the transmitting aircraft.

<u>Note</u>: *"NIC" and "$NAC_P$" as used in the current version (DO-242A) of this MASPS replace the earlier term, "$NUC_P$", used in the first edition (DO-242) of this MASPS. [<<ref. to DO-242, dated February 19, 1998>>].*

<u>Table 2.1.2.3.2.1</u> defines the navigation integrity categories that transmitting ADS-B participants shall (R2.xxx) use to describe the integrity containment radius, $R_C$, associated with the horizontal position information in ADS-B messages from those participants.

**Table 2.1.2.3.2.1: Navigation Integrity Categories (NIC)**

| NIC [Note 2] | Horizontal Containment Radius, $R_C$ | Comment | Notes |
|---|---|---|---|
| 0 | $R_C \geq 37.04$ km (20 NM) | No Integrity | |
| 1 | $R_C < 37.04$ km (20 NM) | RNP-10 containment radius | |
| 2 | $R_C < 14.816$ km (8 NM) | RNP-4 containment radius | [3] |
| 3 | $R_C < 7.408$ km (4 NM) | RNP-2 containment radius | |
| 4 | $R_C < 3.704$ km (2 NM) | RNP-1 containment radius | |
| 5 | $R_C < 1852$ m (1 NM) | RNP-0.5 containment radius | |
| 6 | $R_C < 1111.2$ m (0.6 NM) | RNP-0.3 containment radius | |
| 7 | $R_C < 370.4$ m (0.2 NM) | RNP-0.1 containment radius | |
| 8 | $R_C < 185.2$ m (0.1 NM) | RNP-0.05 containment radius | |
| 9 | $R_C < 75$ m | Future system | |
| 10 | $R_C < 25$ m | e.g., WAAS HPL | |
| 11 | $R_C < 7.5$ m | e.g., LAAS HPL | |

*Notes for Table 2.1.2.3.2.1:*

1. *NIC is reported by an aircraft because there will not be a uniform level of navigation equipage among all users. Although GNSS is intended to be the primary source of navigation data used to report ADS-B horizontal position, it is anticipated that during initial uses of ADS-B or during temporary GNSS outages an alternate source of navigation data may be used by the transmitting A/V for ADS-B position information. The integration of alternate navigation sources is a function that must be performed by a navigation set that is certified to use multiple sources, which then is responsible for supplying the corresponding integrity containment radius (e.g.., HPL). It is important to point out that this is not a function that can be performed by the ADS-B equipment.*

2. *"NIC" in this column corresponds to "$NUC_P$" of Table 2-1(a) in the first version of this MASPS, DO-242, dated February 19, 1998.*

3. *The containment radius for NIC = 2 has been changed (from the corresponding radius for $NUC_P = 2$ in the first edition of this MASP) so as to correspond to the RNP-4 RNAV limit of DO-236A, rather than the RNP-5 limit of the earlier DO-236. This is because RNP-5 is not a recognized ICAO standard RNP value.*

It is recommended that the coded representations of NIC should be such that:

(a) Equipment that conforms to the current version of this MASPS ("version 1" equipment) will recognize the equivalent $NUC_P$ codes from the first edition of this MASPS, and

(b) Equipment that conforms to the initial, DO-242, edition of this MASPS ("version 0" equipment) will treat the coded representations of NIC coming from version 1 equipment as if they were the corresponding "$NUC_P$" values from the initial, DO-242, version of this MASPS.

#### 2.1.2.3.2.2 Navigation Accuracy Category for Position ($NAC_P$)

The Navigation Accuracy Category for Position ($NAC_P$) is reported so that surveillance applications may determine whether the reported position has an acceptable level of accuracy for the intended use.

*Note 1: "NIC" and "$NAC_P$" as used in this MASPS replace the earlier term, "$NUC_P$", used in the initial, DO-242, edition of this MASPS [<<ref. to DO-242, dated February 19, 1998>>].*

Table 2.1.2.3.2.2 defines the navigation accuracy categories that shall (R2.xxx) be used to describe the accuracy of positional information in ADS-B messages from transmitting ADS-B participants.

*Note 2: The Estimated Position Uncertainty (EPU) used in Table 2.1.2.3.2.2 is a 95% accuracy bound. The horizontal EPU (HEPU) is defined as the radius of a circle, centered on the reported position, such that the probability of the actual position being outside the circle is 0.05. Likewise, the vertical EPU (VEPU) is defined as a vertical position limit, such that the probability of the actual vertical position differing from the reported vertical position by more than that limit is 0.05.*

**Table 2.1.2.3.2.2: Navigation Accuracy Categories for Position ($NAC_P$).**

| $NAC_P$ | 95% Horizontal and Vertical Accuracy Bounds (HEPU and VEPU) | Comment |
|---|---|---|
| 0 | HEPU ≥ 18.52 km (10 NM) | Unknown accuracy |
| 1 | HEPU < 18.52 km (10 NM) | RNP-10 accuracy |
| 2 | HEPU < 7.408 km (4 NM) | RNP-4 accuracy |
| 3 | HEPU < 3.704 km (2 NM) | RNP-2 accuracy |
| 4 | HEPU < 1852 m (1NM) | RNP-1 accuracy |
| 5 | HEPU < 926 m (0.5 NM) | RNP-0.5 accuracy |
| 6 | HEPU <555.6 m ( 0.3 NM) | RNP-0.3 accuracy |
| 7 | HEPU < 185.2 m (0.1 NM) | RNP-0.1 accuracy |
| 8 | HEPU <92.6 m (0.05 NM) | RNP-0.05 accuracy |
| 9 | HEPU < 30 m | e.g., GPS – SPS (SA off) |
| 10 | HEPU < 10 m and VEPU< 15 m | e.g., WAAS |
| 11 | HEPU < 3 m and VEPU < 4 m | e.g., LAAS |

#### 2.1.2.3.2.3 Navigation Accuracy Category for Velocity ($NAC_V$)

The velocity accuracy category of the least accurate velocity component being supplied by the reporting A/V's source of velocity data shall (R2.27) be as indicated in Table 2.1.2.3.2.3.

*Note: $NAC_V$ is another name for the parameter that was called $NUC_R$ in the initial (DO-242) version of this MASPS.*

**Table 2.1.2.3.2.3: Navigation Uncertainty Accuracy Categories for Velocity ($NAC_V$).**

| $NAC_V$ | Horizontal Velocity Error (95%) | Vertical Velocity Error (95%) |
|---|---|---|
| 0 | Unknown or ≥ 10 m/s | Unknown or ≥ 50 feet per second |
| 1 | < 10 m/s | < 50 feet per second |
| 2 | < 3 m/s | < 15 feet per second |
| 3 | < 1 m/s | < 5 feet per second |
| 4 | < 0.3 m/s | < 1.5 feet per second |

*Notes to Table 2.1.2.3.2.3:*

1. *When an inertial navigation system is used as the source of velocity information, error in velocity with respect to the earth (or to the WGS-84 ellipsoid used to represent the earth) is reflected in the $NAC_V$ value.*
2. *When any component of velocity is flagged as not available the value of $NAC_V$ will apply to the other components that are supplied.*

*Commentary:*

*Navigation sources, such as GNSS and inertial navigation systems, provide a direct measure of velocity which can be significantly better than that which could be obtained by position differences.*

### 2.1.2.3.2.4 Surveillance Integrity Level (SIL)

The Surveillance Integrity Level (SIL) defines the probability of the integrity containment radius used in the NIC parameter (subsection 2.1.2.3.2.1above) being exceeded, without the possibility of exceeding that limit being detected on board the transmitting A/V. The Surveillance Integrity Limit encoding shall (R2.xxx) be as indicated in Table 2.1.2.3.2.4.

**Table 2.1.2.3.2.4: Surveillance Integrity Levels (SIL).**

| SIL | Probability of Unknowingly Exceeding the $R_C$ Integrity Containment Radius | Comment |
|---|---|---|
| 0 | Unknown | Usable only by "Non-Interfering" Applications (No Hazard Level) |
| 1 | $1 \times 10^{-3}$ per flight hour or per operation | Usable by "Non-Essential" Applications (Minor Hazard Level) |
| 2 | $1 \times 10^{-5}$ per flight hour or per operation | Usable by "Essential" Applications (Major Hazard Level) |
| 3 | $1 \times 10^{-7}$ per flight hour or per operation | Usable by "Critical" Applications (Severe Major Hazard Level) |

#### 2.1.2.3.3 Emergency/Priority Status

The ADS-B system shall (R2.28) be capable of supporting broadcast of emergency and priority status. Status shall (R2.29) include the following:

- No emergency / Not reported
- General emergency
- Lifeguard/medical
- Minimum fuel
- No communications
- Unlawful interference

[***Comment by Jim Maynard***: The source of the information for the "lifeguard/medical" and "minimum fuel" emergency/priority status codes is problematic. Should these emergency/priority status values be dropped from the MASPS?]

#### 2.1.2.3.4 Short Term Intent

Several intent variables are being considered for broadcast by ADS-B. Short term intent information may include Selected Altitude, Target Altitude, Target Heading or Track , intent status, and/or other variables to be determined by ongoing studies.

**Selected Altitude** is an intended altitude that the pilot has selected using the Mode Control Panel (MCP) or Flight Control Unit (FCU). Often this is the altitude to which the aircraft has most recently been cleared by ATC.

**Target Altitude** is the altitude at which the altitude is expected next to change its vertical movement, according to whichever device (MCP/FCU, FMS, etc.) is currently controlling the aircraft. This may be the altitude of the next waypoint in a flight plan that has been entered into the FMS, or the top-of-climb or bottom-of-descent altitude at which the aircraft will level off.

*Note: In Mode S transponders equipped for Downlink of Aircraft Parameters (DAPs), it is expected that Selected Altitude and Target Altitude may be obtainable by a external interrogator (e.g., ground SSR or airborne TCAS/ACAS) that interrogates the transponder for the contents of its GICB register number 20 {hex}.*

**Target Heading/Track** is the anticipated direction for horizontal turn completion, or the intended heading or ground track angle during a constant flight leg segment.

**Intent status** is a binary flag for onboard lateral compliance and a binary flag for onboard vertical compliance, indicating whether the current path is consistent with the broadcast intent variables described above.

#### 2.1.2.3.5 Trajectory Change Intent (Current and Future)

Track extrapolations based on the use of intent data alone are increasingly inaccurate as look-ahead times are increased. The state vector can be augmented with trajectory change points (i.e., intent information) for applications on the receiving A/V or ATS to:

a) support stable separation predictions for long look-ahead times, and in monitoring required operational separations and

b) re-plan flight paths when necessary to resolve detected conflicts (deconfliction) while minimizing deviations from planned flight trajectories.

The ADS-B system shall (R2.30) provide the capability to exchange Trajectory Change Point (TCP) and Trajectory Change Point + 1 (TCP+1) data defined below. ADS-B transmissions shall (r2.31) indicate the ability of the transmitting participant to engage in path monitoring and/or de-confliction operations. The transmitting A/V shall (R2.32) also indicate its capability to use intent information received from other participants.

For certain pairwise operations, an addressed crosslink may be used external to the ADS-B system.

### 2.1.2.3.5.1 Current Trajectory Change Point (TCP)

The TCP from the transmitting aircraft is the point in three-dimensional space where the current operational trajectory is planned to change, and estimated remaining flight time to that point. A TCP transmission indicates that the aircraft intends to fly directly, via a great circle route, to that point. The TCP is defined as a four-element vector consisting of the following:

- Latitude (WGS-84)
- Longitude (WGS-84)
- Altitude (pressure altitude or flight level)
- Time to go (TTG) to the indicated point in space

The TCP required received update rate may be lower than for the state vector. The rate shall (R2.33) be sufficient to ensure continuous positive assessment by the receiving aircraft at least 2 minutes (5 minutes within the range limitations specified in Table 2-3) prior to reaching closes point of approach for class A2 (A3) equipage. In the event of an immediate trajectory change generated via the RNav, new TCP information should be issued immediately.

The augmentation data should be provided as data transmitted indicating planned changes in trajectory. These indications should be provided as TCP information and TCP+1 information described below. This data is required only from participants intending operations based on some level of cooperative conflict management. The TCP and TCP+1 should be used to convey information operationally significant to separation and conflict management. Points constructed by RNav equipment to generate curvilinear paths (e.g., curved transitions between flight legs) should not be conveyed as TCP information.

System designs should be flexible enough to support parameters that might not be available from all ADS-B participating A/Vs. Information acquisition of intent information is provided in Appendix L.

### 2.1.2.3.5.2 Next Trajectory Change Point (TCP+1)

De-confliction is most efficient when adjustments to the flight path can be minimized. Knowledge of planned changes to the current path is needed to support the conflict management tools for stable operational re-planning required due to any conflict that may be predicted.

For the de-confliction capability, additional augmenting information should be provided to determine any change in horizontal and/or vertical flight path planned. The aircraft planning the change shall (R2.34) issue the TCP+1 information at least 5 minutes prior to commencing the trajectory change associated with the TCP. The TCP+1 data to be supplied should provide the target or predicted altitude, the target horizontal coordinates and the estimated time remaining from the time of generation of the message to the estimated time to arrive at TCP+1. Upon initiation of the flight path change at TCP, the TCP+1 should increment to become the new TCP. TCP+1 information shall (R2.35) be provided until commencing the change maneuver. The TCP+1 required transmission rate shall (R2.36) be the same as that of the TCP.

Notes:

1. *TCP and TCP+1 data are provided by broadcast media to supply real-time, event-related data to proximate air and ground systems involved in advanced air operations requiring real time intent detail. Details of more complete flight plan or detailed procedures are conveyed, when required, via addressed datalink media.*

2. *No TCP is needed for speed changes along a trajectory. The data indicating the time to go for TCP and TCP+1 should include any results of planned or predicted changes. For RNav equipment capable of such predictions or scheduling, the time data should include the impacts. Less capable equipment should provide the best estimate available. Air or Ground systems receiving the TCP/TCP+1 data should be capable of applying these data as appropriate to their respective applications in conflict management, sequencing, spacing or conformance.*

3. *TCP and TCP+1 data are envisioned in current planning future procedures in the terminal area and transitions between en route flight regimes to enhance sequencing in arrival and departure. These data are intended for applications by both air and ground systems. The ADS-B system will enable the delivery of TCP and/or TCP+1 data when required by the procedures supported by the RNav onboard the transmitting participant. Receiving participants would use the transmitted capability codes to determine pair-wise compatibility with their respective applications.*

   *For example, at shorter ranges, a pair of points (TCP and TCP+1) could be issued in conjunction with Terminal Maneuvering Area metering operations and/or when maneuvering to join or depart published procedures.*

4. *Lateral TCPs are fly-by points unless indicated to be fly-over. TCP and tCP+1 points are intended to convey trajectory target and trajectory change only. Accordingly, they are not necessarily RNav flight plan waypoints. They must be represented only in binary data form. Example TCPs are top of descent, reach climb altitude or intercept points used to capture procedures or join the flight plan.*

5. *Under some common operational sequences an aircraft may be manually departing or returning to an RNav flight plan. An example case would result from a period of vectored operation by ATS. In such cases the application should determine when to assume the intent is "direct-to" or if the aircraft is operating with a different intent.*

### 2.1.2.4 Other Information

## 2.2 System Performance – Standard Operational Conditions

### 2.2.1 ADS-B System-Level Performance

### 2.2.2 ADS-B System Level Performance – Aircraft Needs

#### 2.2.2.1 Aircraft Needs While Performing Aid to Visual Acquisition

#### 2.2.2.2 Aircraft Needs for Conflict Avoidance and Collision Avoidance

# 3 ADS-B System definition and Functional Requirements

## 3.1 System Scope and Definition of Terms

## 3.2 ADS-B System Description

### 3.2.1 Context Level Description

#### 3.2.1.1 System Level

#### 3.2.1.2 Subsystem Level

#### 3.2.1.3 Functional Level

### 3.2.2 Participant Architecture Examples

### 3.2.3 Equipage Classifications

As illustrated above, ADS-B equipment must be integrated into platform architectures according to platform characteristics, capabilities desired and operational objectives for the overall implementation. The technical requirements of this MASPS have been derived from consolidation of the scenarios presented in Section 2 within the context of the use of the ADS-B system as primary-use capable. The operational capabilities discussed in Section 2 can be divided into four hierarchical levels (with each level including all capabilities of the preceding level:

- Aid to Visual Acquisition: basic state vector information

- Conflict Avoidance and Collision Avoidance: state vector information augmented with identification
- Separation Assurance and Sequencing: pair-wise assessment with strategic intent information (TCP)
- Flight Path Deconfliction Planning: pair-wise assessment with strategic intent information (TCP, TCP+1)

ADS-B equipage is categorized according to the classes listed in Table 3-1. ADS-B equipage classes are defined in terms of the four levels of operational capabilities discussed above. In addition to defining equipage classifications the table summarizes salient features associated with these capabilities. Equipage of a class designated in Table 3-1 shall (R3.1) have, at a minimum, the indicated capabilities.

ADS-B systems used on surface vehicles are expected to require certification similar to that applicable to airborne ADS-B systems in order to ensure conformance to required transmission characteristics. Surface vehicles must have an automatic means to preclude transmission of ADS-B messages when outside the surface movement area..

**Table 3-1: Subsystem Classes and Their Features**

| Class | Subsystem | Example Applications | Features | Comments |
|---|---|---|---|---|
| **Interactive Aircraft/Vehicle Participant Subsystems (Class A)** | | | | |
| A0 | Minimum Interactive Aircraft/Vehicle | Enhanced visual acquisition, conflict detection | Lower TX power and less sensitive RX than Class A1 permitted | Minimum interactive capability with CDTI. |
| A1 | Basic Interactive Aircraft | A0 plus plus airborne conflict management, station keeping | Standard TX and RX | Provides ADS-B based conflict avoidance and interface to current TCAS surveillance algorithms/display. |
| A2 | Enhanced Interactive Aircraft | A1 plus mergin, conflict management, in-trail climb | Standard TX power and more sensitive RX. Interface with avionics source required for TCP data. | Baseline for separation management employing internt information. |
| A3 | Extended Interactive Aircraft | A2 plus long range conflict management | Higher TX power and more sensitive RX. Interface with avionics source required for TCP and TCP+1 data. | Extends planning horizon for strategic separation employing intent information. |
| **Broadcast-Only Participant Subsystems (Class B)** | | | | |
| B1 | Aircraft Broadcast Only | Supports A1 applications for other participants | TX power may be matched to coverage needs. NAV input required. | Enables aircraft to be seen by Class A and Class C users. |
| B2 | Ground Vehicle Broadcast Only | Supports airport surface situational awareness | TX power matched to coverage needs. High accuracy NAV input required. | Enables vehicle to be seen by Class A and Class C users. |
| B3 | Fixed or Movable Obstacle | Supports visual acquisition and airborne conflict management | Fixed or slowly moving coordinates. No NAV input required if obstacle does not move. Collocation with obstacle not required with appropriate broadcast coverage. | Enables NAV hazard to detected by Class A users. |
| **Ground Receive Subsystems (Class C)** | | | | |
| C1 | ATS En Route and Terminal Area Operations | Supports ATS cooperative surveillance | Requires ATS certification and interface to ATS sensor fusion system. | En route coverage out to 200 NM. Terminal coverage out to 60 NM. |
| C2 | ATS Parallel Runway and Surface Operations | Supports ATS cooperative surveillance | Requires ATS certification and interface to ATS sensor fusion system. | Approach coverage out to 10 NM. Surface coverage out to 4 NM. |
| C3 | Flight Following Surveillance | Supports private user operations planning and flight following | Does not require ATS interface. Certification requirements determined by user application. | Coverage determined by application. |

#### 3.2.3.1 Interactive Aircraft/Vehicle ADS-B Subsystems (Class A)

Functional capabilities of interactive aircraft/vehicle subsystems are indicated in the context diagram of Figure 3-4. These subsystems accept own-platform source data, exchange appropriate ADS-B messages with other interactive ADS-B System participants, and assemble ADS-B reports supporting own-platform applications. Such interactive aircraft subsystems, termed Class A subsystems, are further defined by equipage classification according to the provided user capability. The following type of Class A subsystems are defined (Table 3-1):

- Class A0: Supports minimum interactive capability for participants. Broadcast ADS-B messages are based upon own-platform source data. ADS-B messages received from other aircraft support generation of ADS-B reports that are used by on-board applications (e.g., CDTI for aiding visual acquisition of other-aircraft tracks by the own-aircraft's air crew). This equipage class may also support interactive ground vehicle needs on the airport surface.
- Class A1 support all class A0 functionality and additionally supports, e.g., ADS-B airborne conflict management and other applications to ranges < 20 NM.. Class A1 is intended for operation in IFR designated airspace.
- Class A2: Supports all class A1 functionality and additionally provides extended range to 40 NM and information processing to support longer range applications, e.g. oceanic climb to co-altitude. This service requires the broadcast and receipt of trajectory change point data (TCP).
- Class A3: Supports all class A2 functionality and has additional range capability out to 90 NM supporting, e.g., long-range airborne conflict management. Class A3 has the ability to broadcast and receive strategic planning information such as future trajectory change point data (TCP+1).

#### 3.2.3.2 Broadcast-Only Subsystems (Class B)

Some ADS-B system participants may not need to be provided information from other participants but do need to broadcast their state vector and associated data. Class B ADS-B subsystems meet the needs of these participants. Class B subsystems are defined as follows (Table 3-1):

- Class B1: Aircraft broadcast-only subsystem, as shown in Figure 3-3. Class B1 subsystems require an interface with own-platform navigation systems. Two types of equipage, corresponding to equivalent transmit powers and information capabilities as those of class A0 and A1, are permitted within this class. Use of the lower power alternative is determined by the same aircraft operational limits as those given for class A0.
- Class B2: Ground vehicle broadcast-only ADS-B subsystems. Class B2 subsystems require a high-accuracy source of navigation data and a nominal 5 NM effective broadcast range. Surface vehicles qualifying for ADS-B equipage are limited to those that operate within the surface movement area.
- Class B3: Fixed or movable obstacle broadcast-only ADS-B subsystem. Fixed obstacle coordinates may be obtained from available survey data. Collocation of the transmitting antenna with the obstacle is not required as long as broadcast coverage requirements are met. Obstacles qualifying for ADS-B are structures and obstructions identified by ATS authorities as safety hazards.

#### 3.2.3.3 Ground Receive-Only Subsystems (Class C)

Surveillance state vector reports, mode-status reports, and on-condition reports are available from ADS-B system participants within the coverage domain of ground ADS-B receive-only, or Class C subsystems. The following Class C subsystems are defined (Table 3-1):

- Class C1: Ground ATS receive-only ADS-B subsystems for en route and terminal area applications. Class C1 subsystems should meet continuity and availability requirements determined by the ATS provider.
- Class C2: Ground ATS Receive-Only ADS-B Ground ATS receive-only ADS-B subsystems applications. Class C2 subsystems have more stringent accuracy and latency requirements than Class C1 systems. Class C2 systems may be required, depending upon the ADS-B System design, to recognize and process additional ADS-B message formats not processed by Class C1 subsystems.
- Class C3: Flight following surveillance is available from this equipage class for use by private operations planning groups or for provision of flight following and SAR.

## 3.3 System Requirements

### 3.3.1

### 3.3.2 Information Exchange Requirements by Equipage Class

Subsystems must be able to 1) broadcast at least the minimum set of data required for operation in airspace shared with others, and 2) receive and process pair-wise information required to support their intended operational capability. Each equipage class shall (R3.8) meet the required information broadcast and receiving capability at he indicated range to support the applications indicated in Table 3-3.

The rationale for the requirements in Table 3-3 is as follows. Column 1 of Table 3-3 combines the equipage classes (which are based on user operational interests) from Table 3-1 with the required ranges given in Table 3-2. Information exchange requirements by application were taken from Table 2-2 to determine the broadcast and receive data required for each equipage class (column 2 of Table 3-3). A correlation between the equipage class and the ability of that class to support and perform that application was done next. (The determination of the information exchange ability of an equipage class to support a specific application is determined by the information transmitted by that equipage class, while the ability to perform a specific application is determined by the ability of that equipage class to receive and process the indicated information.)

**Table 3-3(a). Interactive Aircraft/Vehicle Equipage Type Operational Capabilities.**

| | | Domain → | Terminal, En Route, Oceanic | | | | | | | | Approach | | Airport Surface | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Equipage Class ↓ | Data Required to Support Operational Capability | | R ≤ 10 NM e.g., Conflict Detection, Enhanced Visual Acquisition | | R ≤ 20 NM e.g., Airborne conflict management, station keeping | | R ≤ 40 NM e.g., Long range conflict management | | R ≤ 90 NM e.g., Long range conflict management | | R ≤ 10 NM e.g., AILS, paired approach | | R ≤ 5 NM e.g., airport surface situational awareness | |
| | TX | RX | Support | Perform | Support | Perform | Support | Perform | Support | Perform | Support | Perform | Support | Perform |
| **A0** **Minimum** R = 10 NM | SV<br>MS-P | SV | Yes | Yes | Yes | No | No | No | No | No | No | No | Yes | Yes |
| **A1** **Basic** R = 20 NM | SV<br>MS | SV<br>MS | Yes | Yes | Yes | Yes | No | No | No | No | Yes | Yes | Yes | Yes |
| **A2** **Enhanced** R = 40 NM | SV<br>MS<br>OC-TCP | SV<br>MS<br>OC-TCP | Yes | Yes | Yes | Yes | Yes | Yes | No | No | Yes | Yes | Yes | Yes |
| **A3** **Extended** R = 90 NM | SV<br>MS<br>OC-TCP<br>OC-TCP+1 | SV<br>MS<br>OC-TCP<br>OC-TCP+1 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |

*Notes: SV = State Vector, MS = Mode Status, OC-TCP = TCP report, OC-TCP+1 = TCP+1 report*

**Table 3-3(b). Broadcast and Receive-Only Equipage Type Operational Capabilities.**

| | Domain → | | Terminal, En Route, Oceanic | | | | | | | | Approach | | Airport Surface | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Equipage Class ↓** | **Data Required to Support Operational Capability** | | **R ≤ 10 NM** e.g., Conflict Detection, Enhanced Visual Acquisition | | **R ≤ 20 NM** e.g., Airborne conflict management, station keeping | | **R ≤ 40 NM** e.g., Long range conflict management | | **R ≤ 90 NM** e.g., Long range conflict management | | **R ≤ 10 NM** e.g., AILS, paired approach | | **R ≤ 5 NM** e.g., airport surface situational awareness | |
| | **TX** | **RX** | **Support** | **Perform** | **Support** | **Perform** | **Support** | **Perform** | **Support** | **Perform** | **Support** | **Perform** | **Support** | **Perform** |
| **A0** **Minimum** R = 10 NM | SV MS | SV | Yes | Yes | Yes | No | No | No | No | No | No | No | Yes | Yes |
| **A1** **Basic** R = 20 NM | SV MS | SV MS | Yes | Yes | Yes | Yes | No | No | No | No | Yes | Yes | Yes | Yes |
| **A2** **Enhanced** R = 40 NM | SV MS OC-TCP | SV MS OC-TCP | Yes | Yes | Yes | Yes | Yes | Yes | No | No | Yes | Yes | Yes | Yes |
| **A3** **Extended** R = 90 NM | SV MS OC-TCP OC-TCP+1 | SV MS OC-TCP OC-TCP+1 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |

*Notes: SV = State Vector, MS = Mode Status, OC-TCP = TCP report, OC-TCP+1 = TCP+1 report*

### 3.3.3 ADS-B Data Exchange Requirements

#### 3.3.3.1 Report Accuracy, Update Period, and Acquisition Range

Report accuracy, update period and acquisition range requirements are derived from the sample scenarios of Chapter 2, and are specified in Table 3-4. The state vecotr report shall (R3.9) meet the update period and 99 percentile update period requirements for each application listed. The rationale for these values is given in Appendix J. the formulation in Appendix J examines the loss of alert time resulting from data inaccuracies, report update interval, and probability of reception. The scope of the analysis was not sufficient to guarantee that the specific operations considered will be supported. Two range values are specified in the table because the alert time requirements are more demanding for short range than they are for surveillance of targets at longer ranges. The first value is based on minimum range requirements. Beyond this range, update period and/or receive probability may be relaxed for each sample scenario, as given by the second value.

For all of the scenarios included in Table 3-4, the state vector shall (R3.10) be acquired with a 95% confidence by the range specified for the scenario. The state vector report is constantly changing and is important for all applications including the safety critical ones. Algorithms designed to use the state vector reports will assume that the information provided is correct. (Some applications may even require that the information is validated before using it.)

Mode-status (MS) and on-condition (OC) report update periods are not specified directly. The minimum range at which mode-status and on-condition reports shall (R3.11) be acquired with 95% confidence is specified in Table 3-4. From this minimum range, combinations of acceptable update periods and receive probabilities for MS and OC reports can be derived for media specific ADS-B implementations.

Acquisition shall (R3.12) be considered accomplished when all report elements required for an operational scenario have been received by an ADS-B participant. Required ranges for acquisition shall (R3.13) be as specified in Table 3-4. In order to meet these requirements, the receiving participant must begin receiving messages at some range outside the minimum range for a given application. Appendix L illustrates examples of expected acquisition time for state vector, monde-status, and on-condition reports as a function of the message period and probability of receipt. Appendix L also treats the necessary acquisition time for segmented state vector messages.

Table 3-4 shows accuracy values in two ways: one describing the ADS-B report information available to all applications, and the other presenting the error budget component allocated to ADS-B degradation of that information. The ADS-B system shall (R3.14) satisfy the error budget requirements specified in the table in order to assure satisfaction of ADS-B report accuracies. Degradation is defined here to mean additional errors imposed by the ADS-B system on position and velocity measurements above the inherent navigation system source errors. The errors referred to in this section are specifically due to ADS-B quantization of state vector information, and other effects such as tracker lag. ADS-B timing and latency errorrs are treated as a separate subject under heading 3.3.3.2. The maximum errors specified in Table 3-4 are limited to contributions from the following two error sources:

- Quantization errors. The relationship between the quantization error and the number of bits required in the ADS-B message are described in Appendix G. This discussion also treats the effect of data sampling time uncertainties on report accuracy.

- Errors due to a tracker. The ADS-B system design may include a smoothing fileter or tracker as described in Appendix G. If a smoothing filter or tracker is used in the ADS-B design, the quality of the reports shall be sufficient (R3.15) to provide equivalent track accuracy implied in Table 3-4 over the period between reports, under target centipetal accelerations of up to 0.5 g with aircraft velocities of up to 600 knots. Tracker lag may be consdered to be a latency (Section 3.3.3.2).

**Table 3-4: ADS-B Report Accuracy, Update Period, and Acquisition Range Requirements**

| Operational Domain | Terminal, En Route, Oceanic | | | | Approach | Airport Surface |
|---|---|---|---|---|---|---|
| **Applicable Range** | $R \le 10$ NM | $R > 10$ NM<br>$R \le 20$ NM | $R > 20$ NM<br>$R \le 40$ NM | $R > 40$ NM<br>$R \le 90$ NM | $R \le 10$ NM | $R \le 5$ NM |
| **Equipage Class** | A0-A3,<br>B1-B3 | A0-A3,<br>B1-B3 | A2-A3 | A3 | A1-A3 | A0-A3,<br>B1-B3 |
| **Example Application** | Conflict Detection, Enhanced Visual Acquisition | Airborne Conflict Management, Station Keeping | Merging, Conflict management, In-trail climb | Long range conflict management | AILS, Paired approach | Surface Situational Awareness |
| **Required State Vector Acquisition Range** | 10 NM | 20 NM | 40 NM | 90 NM [note 3]<br>(120 NM desired) | 10 NM | 5 NM |
| **Required Mode-Status Acquisition Range** | 10 NM | 20 NM | 40 NM | 90 NM [note 3]<br>(120 NM desired) | 10 NM | 5 NM |
| **Required On-Condition Acquisition Range** | n/a | n/a | n/a | 90 NM [note 3]<br>(120 NM desired) | 10 NM | TBD |
| **Required Nominal Update Period ($95^{th}$ Percentile)** | ≤ 3 s (3 NM)<br>≤ 5 s (10 NM) | ≤ 5 s (10 NM)<br>[1 s desired, Note 2]<br>≤ 7 s (20 NM) | ≤ 7 s (20 NM)<br>≤ 12 s (40 NM) | ≤ 12 s | ≤00 ft runway separation)<br>≤ 3 s<br>(1 s desired)<br>(2500 ft runway separation) | ≤ 1.5 s |
| **Required $99^{th}$ Percentile State Vector Report Received Update Period (Coast Interval)** | ≤ 6 s (3 NM)<br>≤ 10 s<br>(10 NM) | ≤ 10 s (10 NM)<br>≤ 14 s (20 NM) | <= 14 s<br>(20 NM)<br>≤ 24 s<br>(40 NM) | ≤ 24 s | ≤ 3 s<br>(1000 ft runway separation)<br>≤ 3 s<br>(1 s desired)<br>(2500 ft runway separation) | ≤ 3 s |
| **Example Permitted Total State Vector Errors Required To Support Application (1 sigma, 1D)** | $\sigma_{hp} = 200$ m<br>$\sigma_{hv}$ = n/a<br>$\sigma_{vp} = 32$ ft<br>$\sigma_{vv} = 1$ ft/s | $\sigma_{hp} = 20/50$ m<br>[note 1]<br>$\sigma_{hv} = 0.6/0.75$ m/s<br>[note 1]<br>$\sigma_{vp} = 32$ ft<br>$\sigma_{vv} = 1$ ft/s | $\sigma_{hp} = 20/50$ m<br>[note 1]<br>$\sigma_{hv} = 0.3/0.75$ m/s<br>[note 1]<br>$\sigma_{vp} = 32$ ft<br>$\sigma_{vv} = 1$ ft/s | $\sigma_{hp} = 200$ m<br>$\sigma_{hv} = 5$ m/s<br>$\sigma_{vp} = 32$ ft<br>$\sigma_{vv} = 1$ ft/s | $\sigma_{hp} = 20$ m<br>$\sigma_{hv} = 0.3$ m/s<br>$\sigma_{vp} = 32$ ft<br>$\sigma_{vv} = 1$ ft/s | $\sigma_{hp} = 2.5$ m<br>[note 9]<br>$\sigma_{hv} = 0.3$ m/s<br>$\sigma_{vp}$ = n/a<br>$\sigma_{vv}$ = 1 n/a |
| **Required maximum error contribution due to ADS-B (1 sigma, 1D)** | $\sigma_{hp} = 20$ m<br>$\sigma_{hv} = 0.25$ m/s<br>$\sigma_{vp} = 30$ ft<br>$\sigma_{vv} = 1$ ft/s [note 1] | | | | | |

Definitions:

$\sigma_{hp}$ = standard deviation of horizontal position error

$\sigma_{hv}$ = standard deviation of horizontal velocity error

$\sigma_{vp}$ = standard deviation of vertical position error

$\sigma_{vv}$ = standard deviation of vertical velocity error

*Notes for Table 3-4:*

1. *The lower number represents the desired accuracy for best operational performance and maximum advantage of ADS-B. the higher number, representative of GPS standard positioning service, represents an acceptable level of ADS-B performance, when combined with barometric altimetry.*

2. *The analysis in Appendix J indicates that a 3-second report received update period for the full state vector will yield improvements in both safety and alert rate relative to TCAS II, which does not measure velocity. Further improvement in these measures can be achieved by providing a one-second report received update rate. Further definition of ADS-B separation and conflict avoidance system(s) may result in refinements to the values in the Table.*

3. *The 90 NM range requirement applies in the forward direction. The required range aft is 30 NM (40 NM desired). The required range 90 degrees to port and starboard if 45 NM (60 NM desired). (See Appendix H.)*

4. *n/a = not applicable; TBD = To be defined.*

5. *Requirements apply to both aircraft and vehicles.*

6. *Supporting analysis for update period and update probability are provided in Appendices J and L.*

7. *The delay for MS or OC report updates after a MX or OC stand change should be no more than the coast interval associated with the state vector report (with 95% confidence).*

8. *The position accuracy requirement for aircraft on the airport surface is stated with respect to the certified navigation center of the aircraft.*

9. *This row represents the allowable contribution to total state vector error from ADS-B.*

10. *The horizontal velocity error requirements apply to aircraft speeds of up to 600 knots. Accuracies required for velocities above 600 knots are TBD.*

11. *Specific system parameter requirement in Table 3-4 can be waived provided that the system designer shows that the applicaton design goals stated in Appendix J or equivalent system level performance can be achieved.*

12. *Update periods for the SV have been emphasized in determining link related performance requirements in this table. Lower rates of MC and OC are under development. These reports should be made available to support the operational capabilites using considerations equivalent to the SV. The requirement should be optimized to ensure that the refresh/update of reports is appropriate for the quipment classes and the operations being supported. Refer to the analysis presneted in Appendix L for further details.*

### 3.3.3.2 Report Latency and Report Time Error Requirements

## 3.4 ADS-B Report Definitions

### 3.4.1 Report Assembly Design Considerations

Three report types are defined as ADS-B outputs to applications. They provide flexibility in meeting delivery and performance requirements for the information needed to support the operations identified in Section 2. Report types, also shown in Figure 3-8, are:

- Surveillance State Vector Report (SV)
- Mode/Status Report (MS)
- On-Condition Report (OS)

All interactive participants must receive messages and assemble reports specified for the respective equipage class (Table 3.3(a)). All receive-only participants must receive messages and assemble reports as specified for the respective equipage class (Table 3-3(b)). All transmitting participants must output at least the minimum data for the SV and partial MS reports. The minimum requirements for exchanged information and report contents applicable for equipage classes are provided in Section 3.4.4.

### 3.4.2 ADS-B Message Exchange Technology Considerations in Report Assembly

### 3.4.3 Specific ADS-B Report Definitions

### 3.4.3.1 State Vector Report

The state vector (SV) report contains information about an aircraft or vehicle's current kinematic state. (Measures of the state vector quality are contained in the Mode Status Report, section 3.4.3.2 below.) Paragraph 3.4.4 defines the required capabilities for each Subsystem Class defined in Section 3.2.2. Contents of the state vector are summarized in Table 3.4.3.1. Required update rates for this report, described by operational capability and operating range, are given in Section 3.3.3.

The surveillance SV report for each acquired participant contains the participant address and address qualifier for correlation purposes. Geometric based state vector information is referenced to the WGS-84 ellipsoid and consists of latitude, longitude, height above the ellipsoid, horizontal velocity, and rate of change ofheight above the ellipsoid. Other state vector information includes pressure altitude, pressure altitude rate, and the heading of participants on the surface.

*Note: Airspeed and heading for airborne participants are reported in the Air Referenced Velocity report, which is one of the On Condition reports. See section 3.4.3.4 below.*

Pressure altitude, which is currently reported by aircraft in SSR Mode C and Mode S, will also be transmitted in ADS-B messages and reported to client applications in SV reports. The pressure altitude reported (SV element 8a) shall (R3.34) be derived from the same source as the pressure altitude reported in Mode C and Mode S for aircraft with both transponder and ADS-B.

*Time-critical* state vector elements are those indicated by bullets in the "Time-Critical SV Elements" column of Table 3.4.3.1. For systems utilizing segmented messages for SV data, time-critical state vector elements not updated in the current received message shall (R3.35) be estimated when the report is updated; otherwise SV elements shall (R3.35) be updated as new data is received.

State vector elements indicated by "R" in the "required from surface participants" column of Table 3-5 shall (R3.xxx) be transmitted by ADS-B participants that indicate that they are on the surface. Likewise, SV elements indicated by "R" in the "required from airborne participants" column shall (R3.xxx) be transmitted by ADS-B participants that do not indicate that they are on the surface. If a transmitting ADS-B participant does transmit the state vector elements indicated by "O" (for optional) in these columns, then it shall (R3.xxx) indicate that is transmitting those optional elements in the appropriate subfield of the messages that it transmits to support the MS report.

The time of applicability relative to local system time shall (R3.37) be updated with each State Vector report update. For other elements of the SV report, the report assembly function shall (R3.38) either provide updates when data is received or indicate "no data available" if no data are received in the preceding 10 second period.

The "Report Mode" SV element provides a positive indication when SV acquisition is complete and all applicable data sets and modal capabilities have been determined for the participant or that a default condition is determined by the Report Assembly function.

**Table 3.4.3.1. State Vector Report Definition.**

| | SV Elem. # | Contents [# of bits] | [Notes] | Time-Critical SV Elements | Required from airborne participants | Required from surface participants | Minimum Equipage Level Which Must Transmit This Element | Reference Section |
|---|---|---|---|---|---|---|---|---|
| **ID** | 1a | Participant Address [24 bits] | | | **R** | **R** | A0 | 2.1.2.1.2.1 |
| | 1b | Address Qualifier [4 bits] | | | **R** | **R** | A0 | 2.1.2.1.2.2 |
| **Geometric Position** | 2a | Latitude (WGS-84) | | • | **R** | **R** | A0 | |
| | 2b | Longitude (WGS-84) | | • | **R** | **R** | A0 | 2.1.2.3.1 |
| | 2c | Horizontal Position Valid [1 bit] | | • | **R** | **R** | A0 | |
| | 3a | Geometric Altitude | [2] | • | **R** | N | A0 | 2.1.2.2.1.2 |
| | 3b | Geometric Altitude Valid [1 bit] | [2] | • | **R** | N | A0 | |
| **Horizontal Velocity** | 4a | North Velocity while airborne | [2] | • | **R** | N | A0 | |
| | 4b | East Velocity while airborne | [2] | • | **R** | N | A0 | 2.1.2.2.2.1 |
| | 4c | Airborne Horiz. Velocity Valid [1 bit] | [2] | • | **R** | N | A0 | |
| | 5a | Ground Speed on the surface [TBD] | [1] | • | N | **R** | A0 | 2.1.2.2.2.1 |
| | 5b | Surface Ground Speed Valid [1 bit] | [1] | • | N | **R** | A0 | |
| **Heading** | 6a | Heading while on the Surface | [1, 3, 4] | • | N | **R** | A0 | 2.1.2.2.3 |
| | 6b | Heading Valid | [1, 3, 4] | • | N | **R** | A0 | |
| **Baro Altitude** | 7a | Barometric Pressure Altitude | [2] | • | **R** | N | A0 | 2.1.2.2.1.2 |
| | 7b | Pressure Altitude Valid | [2] | • | **R** | N | A0 | |
| **Vertical Rate** | 8a | Vertical Rate (Baro/Geo) | [2, 3] | • | **R** | N | A0 | 2.1.2.2.2.2 |
| | 8b | Vertical Rate Valid | [2, 3] | • | **R** | N | A0 | |
| | 8c | Alternate Type Vertical Rate (Geo/Baro) | | • | O | N | - | 2.1.2.2.2.2 |
| | 8d | Alternate Type Vertical Rate Valid | | • | O | N | - | |
| **TOA** | 9 | Time Of Applicability [0.2 s resolution] | | • | **R** | **R** | A0 | 2.1.1.4 |
| **Report Mode** | 10 | Report Mode (Report Assembly Function Mode For This Target: Acquisition, Track, Or Default) | | | **R** | **R** | A0 | |

*Notes for Table 3.4.3.1*:

*[1] A transmitting ADS-B subsystem shall provide those SV elements marked as "required from surface participants" (a) when the own-ship aircraft is known to be on the aircraft surface, and (b) when it is not known whether or not the aircraft is on the surface..*

*[2] A transmitting ADS-B subsystem shall provide those SV elements marked as "required from airborne participants" (a) when the own-ship aircraft is known to be airborne, and (b) when it is not known whether or not the aircraft is airborne.*

*[3] Data type (True vs. Magnetic for heading, Barometric vs Geometric for vertical rate) is provided in the Mode Status Report.*

*[4] An ADS-B participant on the airport surface may transmit track angle instead of heading, but only if it does not have a source of heading information. A surface participant that transmits track angle rather than heading should be sure to clear the SV element #6b, "heading valid," when the A/V is moving so slowly that the track angle does not meet the required accuracy for heading.*

### 3.4.3.2 Mode Status Reports

The mode-status (MS) report contains current operational information about the transmitting participant. This information includes participant type, mode specific parameters, status data needed for certain pairwise operations, and assessments of the integrity and accuracy of position and velocity elements of the SV report. These elements require lower update rates than the SV report. Specific requirements for a participant to supply data for and/or generate this report subgroup will vary according to the equipage class of each participant. Paragraph 3.4.4 defines the required capabilities for each Equipage Class defined in Section 3.2.2. Equipage classes define the level of MS information to be exchanged from the source participant to support correct classification onboard the user system.

The Mode-Status report for each acquired participant contains the unique participant address for correlation purposes, static and operational mode information and Time of Applicability. Contents of the Mode-Status report are summarized in Table 3.4.3.2.

The static and operational mode data includes the following information:

- Capability Class Codes – used to indicate the capabilities of a transmitting ADS-B participant.
- Operational Mode Specific Parameters – e.g., Speed target, Mag/True track, IAS/TAS.

For each participant the Mode-status report shall (R3.41) be updated and made available to ADS-B applications any time a new message containing all, or a portion of, its component information is accepted from that participant. For all applications other than Aid to Visual Acquisition the required MS report must be available to qualify for ADS-B operations.

The time of applicability relative to local system time shall (R3.42) be updated with every Mode-status report update. For all elements of MS report the assembly function shall (R3.43) provide update when received or indicate “no data available” is none is received in the preceding 10 second period.

**Table 3.4.3.2: Mode-Status (MS) Report Definition.**

| | MS Elem. # | Contents [# of bits] [Notes] | Minimum Equipage Level Which Must Transmit This MS Report Element | Reference Section |
|---|---|---|---|---|
| **ID** | 1a | Participant Address [24 bits] | A0 | 2.1.2.1.2.1 |
| | 1b | Address Qualifier [4 bits] | A0 | 2.1.2.1.2.2 |
| | 2 | Call sign [up to 8 alpha-numeric characters] | A0 | 2.1.2.1.1 |
| | 3 | Participant Category [5 bits] | A0 | 2.1.2.1.3 |
| | 4 | Aircraft Size Code [4 bits] [Note 1] | -- | 2.1.2.1.4 |
| **Status** | 5 | Surveillance Support Code [1 bit] [Note 2] | A0 | |
| | 6 | Emergency/Priority Status [3 bits] | A0 | 2.1.2.3.3 |
| **CC** | 7 | Capability Class Codes | A0 | 2.1.2.3.1 |
| | | 7a: CDTI display enabled [1 bit] | A0 | |
| | | 7b: TCAS enabled [1 bit] | A0 | |
| | | 7c: Service Level [TBD:2 bits?] | A0 | |
| | | 7d: Can send OC-ARV report elements [1 bit] | A2 | |
| | | 7e: Can send Target Altitude [1 bit] | A2 | |
| | | 7f: Can send Target Heading / Track Angle [1 bit] | A2 | |
| **OM** | 8 | Operational Mode Specific Parameters | | |
| | | 8a: Sending OC-ARV report elements [1 bit] | -- | |
| | | 8b: Sending Target Altitude [1 bit] | A2 | |
| | | 8c: Sending Target Heading / Track [1 bit] | A2 | |
| | | 8d: ACAS/TCAS resolution advisory active [1 bit] | -- | |
| | | 8e: Sending TCP information [1 bit] | A2 | |
| | | 8f: Sending TCP+1 information [1 bit] | A3 | |
| | | 8g: Sending TCP+2 information [1 bit] | A3 | |
| | | 8h: Sending TCP+3 information [1 bit] | A3 | |
| **SV Integrity and Accuracy** | 9a | NIC [4 bits] | A0 | 2.1.2.3.2.1 |
| | 9b | $NAC_P$ [4 bits] | A0 | 2.1.2.3.2.2 |
| | 9c | $NAC_V$ [2 bits] | A0 | 2.1.2.3.2.3 |
| | 9d | SIL [2 bits] | A0 | 2.1.2.3.2.4 |
| **Data Reference** | 10a | True/Magnetic Heading [1 bit] | | |
| | 10b | IAS/TAS/Mach Airspeed [2 bits] | | |
| | 10c | Primary Vertical Rate Type (Baro./Geo.) [1 bit] | | |
| | 11 | Flight Mode Specific Data [Note 3] | A0 | |
| **TOA** | 12 | Time of Applicability [1 s resolution] | A0 | 2.1.1.4 |

*Notes for Table 3.4.3.2:*

1. *The aircraft size code (SV element 4) only has to be transmitted by aircraft above a certain size, and only while those aircraft are on the ground. (See section 2.1.2.1.4 for details.)*
2. *The Surveillance Support code can be Normal or Default. "Normal" means that for the stated capability class codes (field 7), all data are reliable. "Default" means that the transmitting ADS-B participant advises that some transmitted data are not reliable or unavailable.*
3. *Flight mode specific data will be defined in a lower level of documentation and be included through revision to the MASPS. Examples are: touchdown speed and pair-wise operational capabilities.*

### 3.4.3.3 On-Condition Reports

The following sections (3.4.3.4 to 3.4.3.8) describe various On Condition (OC) reports. The OC reports are those for which messages are not transmitted all the time, but only when certain conditions are satisfied. Several OC report types are currently defined, as follows:

**OC-ARV:** Air Referenced Velocity Report (section 3.4.3.4).

**OC-TSR**: Target State Report (section 3.4.3.5).

**OC-TCP, OC-TCP+1, OC-TCP+2, OC-TCP+3**: Trajectory Change Reports (section 3.4.3.6). This may be for either the current trajectory change point towards which the aircraft is being controlled (the TCP), or for subsequent trajectory change points (TCP+1, TCP+2, TCP+3).

**OC-RFI**: Request For Information Report (section 3.4.3.7). The OC-RFI report is proposed as a way by which one ADS-B participant may request another ADS-B participant to broadcast messages to support other OC reports.

Other OC reports may be defined in future versions of this MASPS. Examples of such reports are to be found in Appendix M.

### 3.4.3.4 On Condition – Air Referenced Velocity (OC – ARV) Report

The On Condition – Air Referenced Velocity (OC – ARV) report contains velocity information that is not required from all airborne ADS-B transmitting participants, and that may not be required at the same update rate as the position and velocity elements in the SV report. Table 3.4.3.4 lists the elements of the OC-ARV Report.

**Table 3.4.3.4: OC-ARV Report Definition.**

| | OC-ARV Elem. # | Contents [number of bits] [Notes] | Minimum Equipage Level Which Must Be Able To Transmit This Report Element | Reference Section |
|---|---|---|---|---|
| | 1a | Participant Address [24 bits] | -- | 2.1.2.1.2.1 |
| | 1b | Address Qualifier [4 bits] | -- | 2.1.2.1.2.2 |
| **Airspeed** | 2a | Airspeed [TBD bits] | A3 | |
| | 2b | Airspeed Valid [1 bit] | A3 | |
| **Heading** | 3a | Heading [TBD bits] [Note 1] | A3 | |
| | 3b | Heading Valid [1 bit] | A3 | |
| **TOA** | 4 | Time of Applicability [1 s resolution] | A3 | |

*Notes for Table 3.4.3.4:*

1. *The heading reference direction (true north or magnetic north) is given in the MS report..*

**Conditions for transmitting OC-ARV report elements.** An airborne ADS-B participant of equipage class A3 [A2 or A3??] shall (R3.xx) transmit messages to support the OC-ARV report when either of the following conditions is met:

- The participant is capable of transmitting the airspeed report element (as indicated in the capability codes (CC) element of the MS report) and it has received an OC-RFI report (see section 3.4.3.7) requesting that it transmit airspeed; or
- The participant is capable of transmitting the heading report element (as indicated in the capability codes (CC) element of the MS report) and it has received an OC-RFI report (section 3.4.3.7) requesting that it transmit heading.

An ADS-B participant that is transmitting messages to support the OC-ARV report shall (R2.xx) cease such transmissions when at least [TBD: 2 minutes?] have elapsed without its receiving an OC-RFI report requesting transmission of messages to support the OC-ARV report.

**Update Interval for OC-ARV report elements.** <<Text TBD>>

### 3.4.3.5 On Condition – Target State Report (OC-TSR)

The On Condition – Target State Report (OC – TSR) contains information about the current heading or altitude towards which the aircraft is being controlled.

**Table 3.4.3.4: OC-TSR Report Definition.**

| | OC-ARV Elem. # | Contents [number of bits] [Notes] | Minimum Equipage Level Which Must Be Able To Transmit This Report Element | Reference Section |
|---|---|---|---|---|
| **ID** | 1a | Participant Address [24 bits] | -- | 2.1.2.1.2.1 |
| | 1b | Address Qualifier [4 bits] | -- | 2.1.2.1.2.2 |
| **Selected Heading (or Track Angle)** | 2a | Target Heading or Track Angle [ ?? bits] | A3 | |
| | 2b | Orientation Type (Heading vs. Track Angle) [1 bit] | A3 | |
| | 2c | Target Heading or Track Angle Validity [1 bit] | A3 | |
| | 2d | Target Heading/Track Source Indicator [2 bits ?] | A3 | |
| | 2e | Target Heading/Track Mode Indicator [2 bits ?] | A3 | |
| **Target Altitude** | 3a | Target Altitude [?? Bits] | A3 | |
| | 3b | Target Altitude Type | A3 | |
| | 3b | Target Altitude Valid [1 bit] | A3 | |
| | 3c | Target Altitude Source Indicator [2 bits?] | A3 | |
| | 3d | Target Altitude Mode Indicator [2 bits?] | A3 | |
| **TOA** | 4 | Time of Applicability [1 s resolution] | A3 | 2.1.1.4 |

**Conditions for transmitting OC-TSR report elements.** An ADS-B participant in an airborne aircraft shall (R3.xx) transmit messages to support the OC-TSR report when any of the following conditions are met:

<<Text TBD >>

**Update Interval for OC-TSR report elements.** <<Text TBD>>

#### 3.4.3.5.1 Target Heading or Track Angle

The target heading or track angle (OC-TSR element #2a) may be either the current heading (track angle) if in heading (track angle) hold mode, or the next intended heading (track angle) towards which the aircraft is being controlled.

The orientation type (heading or track angle) is conveyed in OC-TSR element #2b. This field shall be ZERO to indicate that element #2a conveys target heading, or ONE to indicate that element #2a conveys target track angle. The reference direction (true north or magnetic north) is conveyed in the MS report.

The validity flag for the target heading, OC-TSR element #2c, shall be ONE to indicate that data in the target heading or track angle field (element #2a) is valid, or ZERO otherwise.

The target heading/track source indicator (OC-TSR element #2d) is a two-bit field that is reserved for future definition. ***<<Need text to define the values of this field.>>***

The mode indicator for target heading/track angle (OC-TSR element #2e) is a two-bit field that is reserved for future definition. ***<<Need text to define the values of this field.>>***

#### 3.4.3.5.2 Target Altitude

The target altitude (OC-TSR element #3a) may be either the current altitude, if in altitude hold mode, or the next intended altitude towards which the aircraft is being controlled.

### 3.4.3.6 On Condition – Trajectory Change (OC-TCP, OC-TCP+1, etc.) Reports

Table 3.4.3.6 shows the overall structure for On Condition – Trajectory Change Point (OC-TCP) reports. The structure shown here is intended to accommodate up to four trajectory change points, and to provide for additional fields as more types and subtypes of TCP reports are developed for later versions of this MASPS.

**<u>Table 3.4.3.6</u>: Generalized OC-TCP Report Definition.**

| | | | | Minimum Equipage Level Which Must Be Able To Transmit This OC-TCP Report Element | |
|---|---|---|---|---|---|
| | **OC-TCP Elem. #** | **Contents [number of bits]** | **[Notes]** | | **Reference Section** |
| **ID** | 1a | Participant Address [24 bits] | | A2 | 2.1.2.1.2.1 |
| | 1b | Address Qualifier [4 bits] | | A2 | 2.1.2.1.2.2 |
| **TCP Type** | 2a | TCP Type [2 bits] | [Note 1] | A2 | |
| **TCP #** | 3 | TCP # (“N” in “TCP+N”) [2 bits] | [Note 2] | A2 | |
| **TOA** | 4 | Time of Applicability [1 s resolution] | | A2 | 2.1.1.4 |
| **Other Information** | -- | [Variable Information] | [Note 3] | A2 | |

*<u>Notes for Table 3.4.3.4</u>:*

1. *Depending on the value of the TCP type field (TCP report element #2a), the type field may be supplemented by a subtype field (element 2b) in the variable “other information” part of the TCP report.*

2. *If the TCP type (element 2a) is 0, only two values (0 and 1) are valid in the TCP # field. (This is for compatibility with ADS-B transmitting equipment that conforms to the initial, DO-242, version of this MASPS.)*

3. *The “other information” part of a TCP report will vary with different values of the TCP Type (element 2a) field. Some TCP types will include a TCP Subtype (element 2b) in the variable “other information” part of the TCP report.*

**Conditions for transmitting OC-TCP report elements.** An ADS-B participant in an airborne aircraft shall (R3.xx) transmit messages to support the OC-TCP report when any of the following conditions are met:

<<Text TBD >>

**Update Interval for OC-TCP report elements.** <<Text TBD>>

### 3.4.3.6.1 Type 0 TCP Report Format

Table 3.4.3.6.1 shows the structure of Type 0 TCP reports. This report structure accommodates the fields of TCP and TCP+1 reports as they were defined in the initial version (DO-240) of this MASPS.

**Table 3.4.3.6.1: Type 0 TCP Report Definition.**

| | OC-TCP Elem. # | Contents [number of bits] [Notes] | Minimum Equipage Level Which Must Be Able To Transmit This OC-TCP Report Element | Reference Section |
|---|---|---|---|---|
| **ID** | 1a | Participant Address [24 bits] | A2 | 2.1.2.1.2.1 |
| | 1b | Address Qualifier [4 bits] | A2 | 2.1.2.1.2.2 |
| **TCP Type** | 2a | TCP Type **(Value = 0)** [2 bits] [Note 1] | -- | |
| **TCP #** | 3 | TCP no. ("N" in "TCP+N") [2 bits] [Note 2] | A2 | |
| **TOA** | 4 | Time of Applicability [1 s resolution] | A2 | 2.1.1.4 |
| **TCP Horiz. Position** | 4a | TCP Latitude [TBD resolution] | A2 | |
| | 4b | TCP Longitude [TBD resolution] | A2 | |
| | 4c | TCP Horizontal Position Valid [1 bit] | A2 | |
| **TCP Vertical Position** | 5a | TCP Altitude [TBD resolution] | A2 | |
| | 5b | TCP Altitude Valid [1 bit] | A2 | |
| **Time To Go (TTG)** | 6a | TCP TTG in seconds [TBD resolution] | A2 | |
| | 6b | TCP TTG Valid [1 bit] | A2 | |

*Notes for Table* 3.4.3.6.1::

1. *ADS-B transmitting equipment that conforms to the initial (DO-242) version of this MASPS need not transmit messages that convey the TCP Type field. Therefore, for backwards compatibility, ADS-B receiving equipment should interpret messages that convey information for TCP reports, but do not contain the TCP Type field, as if those messages specified TCP Type = 0.*
2. *Only two values (0 and 1) are valid in the TCP # field. (This is for compatibility with ADS-B transmitting equipment that conforms to the initial, DO-242, version of this MASPS.)*

### 3.4.3.6.2 Type 1 TCP Report Format

Table 3.4.3.6.2 shows the structure of Type 1 TCP reports. This report structure accommodates the fields of TCP, TCP+1, TCP+2, and TCP+3 reports as they are defined in the current version (DO-240A) of this MASPS.

**Table 3.4.3.6.2: Type 1 TCP Report Definition**

| | OC-TCP Elem. # | Contents [number of bits] [Notes] | Minimum Equipage Level Which Must Be Able To Transmit This OC-TCP Report Element | Reference Section |
|---|---|---|---|---|
| **ID** | 1a | Participant Address [24 bits] | A2 | 2.1.2.1.2.1 |
| | 1b | Address Qualifier [4 bits] | A2 | 2.1.2.1.2.2 |
| **TCP Type** | 2a | TCP Type **(Value = 1)** [2 bits] [Note 1] | -- | |
| **TCP #** | 3 | TCP no. ("N" in "TCP+N") [2 bits] [Note 2] | A2 | |
| **TOA** | 4 | Time of Applicability [1 s resolution] | A2 | 2.1.1.4 |
| **TCP Horiz. Position** | 4a | TCP Latitude [TBD resolution] | A2 | |
| | 4b | TCP Longitude [TBD resolution] | A2 | |
| | 4c | TCP Horizontal Position Valid [1 bit] | A2 | |
| **TCP Vertical Position** | 5a | TCP Altitude [TBD resolution] | A2 | |
| | 5b | TCP Altitude Valid [1 bit] | A2 | |
| **Time To Go (TTG)** | 6a | TCP TTG in seconds [TBD resolution] | A2 | |
| | 6b | TCP TTG Valid [1 bit] | A2 | |

*Notes for Table 3.4.3.6.2::*

1. *ADS-B transmitting equipment that conforms to the initial (DO-242) version of this MASPS need not transmit messages that convey the TCP Type field. Therefore, for backwards compatibility, ADS-B receiving equipment should interpret messages that convey information for TCP reports, but do not contain the TCP Type field, as if those messages specified TCP Type = 0.*
2. *Four possible values (0, 1, 2, and 3) are valid in the TCP # field.*

### 3.4.3.7 On Condition – Request for Information (OC-RFI) Report

*Note: The proper place for this information is Appendix M, not the body of the MASPS. It is shown here in this draft only by way of example, to show how this kind of OC report might later be incorporated in the body of the MASPS.*

Table 3.4.3.7 shows the format of a possible future On Condition report by which one ADS-B participant might request On Condition reports to be transmitted by another ADS-B participant. The "condition" that causes a participant to transmit a message to support this report is that the participant desires to participate in a pairwise operation with the other participant – the "addressee" to which the message is directed.

*Note: Strictly speaking, this report may not be proper for a broadcast system such as ADS-B, because the message that transmits this information is not really broadcast, but is addressed to a particular ADS-B participant. Indeed, messages to support the OC-RFI report might not be transmitted on an ADS-B data link at all, but instead be transmitted on a different data link, that provides an addressed (rather than broadcast) communication service.*

**Table 3.4.3.7: On Condition – Request For Information (OC-RFI) Report Definition.**

| | OC-SO Element # | Contents | # of Bits | Section References | |
|---|---|---|---|---|---|
| **Transmitting Participant ID** | 1a | Transmitting Participant Address | 16 | 2.1.2.1.2.1 | |
| | 1b | Transmitting Participant's Address Qualifier | 4 | 2.1.2.1.2.2 | |
| **Addressee ID** | 2a | Addressee's Participant Address | 16 | 2.1.2.1.2.1 | |
| | 2b | Addressee's Address Qualifier | 4 | 2.1.2.1.2.2 | |
| **Requested Information** | 3 | Requested Information | 32 | | |
| | | 3a: Request OC-ARV information | 1 | 3.4.3.4 | |
| | | 3b: Request OC-TSR information | 1 | 3.4.3.5 | |
| | | 3c: Request OC-TCP information | 1 | 2.1.2.3.5.1, 2.1.2.3.5.2 | 3.4.3.6 |
| | | 3d: Request OC-TCP+1 information | 1 | | |
| | | 3e: Request OC-TCP+2 information | 1 | | |
| | | 3f: Request OC-TCP+2 information | 1 | | |
| | | 3g: Request OC-AILS information | 1 | 3.4.3.8 | |
| | | (Bits reserved for future definition.) | 25 | | |
| **TOA** | 4 | Time of Applicability [1 s resolution] | TBD | | |

**Conditions for transmitting OC-RFI report elements.** An ADS-B participant in an airborne aircraft shall (R3.xx) transmit messages to support the OC-TCP report when any of the following conditions are met:

<<Text TBD >>

**Update Interval for OC-RFI report elements.** <<Text TBD>>

<<Text TBD >>

### 3.4.3.8 On Condition – Airborne Information for Lateral Spacing (OC-AILS) Report

*Note:* *This information is copied from Appendix M, where it should remain. It is shown here in this draft only by way of example, to show how this kind of OC report might later be incorporated in the body of the MASPS.*

Table 0 shows the format of a possible future On Condition – Airborne Information for Lateral Spacing (OC-AILS) report.

**Table 0: OC-AILS Report Definition.**

| | OC-AILS Element # | Contents | Section Reference |
|---|---|---|---|
| **ID** | 1a | Participant Address | 2.1.2.1.2.1 |
| | 1b | Address Qualifier | 2.1.2.1.2.2 |
| **Turn Rate** | 2 | Turn Rate | TBD |
| **Horizontal Position** | 3a | Latitude | |
| | 3b | Longitude | |
| **TOA** | 4 | Time of Applicability | |

**Conditions for transmitting OC-AILS report elements.** An ADS-B participant in an airborne aircraft shall (R3.xx) transmit messages to support the OC-TCP report when any of the following conditions are met:

<<Text TBD >>

**Update Interval for OC-AILS report elements.** <<Text TBD>>

### 3.4.4 Minimum ADS-B Report Requirements for Equipage Classes

Equipage classes are defined to accommodate tiered capabilities according to increasingly complex operational objectives while preserving basic interoperability between classes. Equipage decisions are determined on the basis the operational approval desired. Each equipage class discussed in Table 3-1 is required to receive messages and process the recovered information into specific ADS-B reports according to the applicable capability. This section defines the required ADS-B report capabilities for each class.

For certain pair-wise operations, more data is required to support the desired applications than that provided by the state vector alone. Table 3-3 states general requirements to perform or support certain operational capabilities. The receiving participant must determine the pair-wise capabilities between own and the transmitting (other) participant. This capability determination is determined by reading the class code (item 6) defined in the Mode-Status report. Therefore, this section also identifies the transmitted information required from each class operating within the ADS-B system.

#### 3.4.4.1 Interactive Aircraft/Vehicles Subsystems (Class A)

Table 3-8(a) defines requirements for the contents of ADS-B reports to be provided by each Class A equipment. Table 3-8(b) defines requirements for minimum information to be broadcast by class A equipment.

**Table 3-8(a): Class A Equipment ADS-B Report Contents**

| Equipage Class | Interactive Aircraft/Vehicles Operational Capabilities | | | | | |
|---|---|---|---|---|---|---|
| | Aid to Visual Acquisition | Conflict Avoidance | Separation Assurance and Sequencing | Flight Path Deconfliction Planning | Simultaneous Approaches | Airport Surface |
| | **ADS-B Output Reports Required** | | | | | |
| **A0** **Basic VFR** Aircraft / Ground Vehicles | SV | Not Applicable | Not Applicable | Not Applicable | Not Applicable | SV |
| **A1** **Basic IFR** Aircraft [Note 1] and Ground Vehicles | SV MS [Note 4] | SV MS [Note 4] | Not Applicable | Not Applicable | SV MS [Note 4, Note 6] | SV MS [Note 4] |
| **A2** **Enhanced IFR** Aircraft Only | SV MS [Note 5] | SV MS [Note 5] | SV MS [Note 5] | Not Applicable | SV MS [Note 5] | SV MS [Note 5] |
| **A3** **Extended Capability** Aircraft Only | SV MS [Note 5] OC | SV MS [Note 5] OC | SV MS [Note 5] OC | SV MS [Note 5] OC | SV MS [Note 5] OC | SV MS [Note 5] OC |

*Notes for Table 3-8(a):*

1. *ADS-B Collision Avoidance can be performed without acquiring Mode-status data. Mode-status data is needed in applications which determine separation assessment based on the information provided in Partial MS report. Such assessments and predictions are performed well outside the operational conditions of Collision Avoidance.*
2. *Numbers (#) refer to data elements in Tables 3.4-1, 3.4-2, and 3.4-3.*
3. *All SV (state vector) entries require elements 1 through 17.*
4. *Mode-status elements 1 though 6 and 12 required.*
5. *Mode-status elements 1 through 12 required.*
6. *Not applicable for ground vehicles.*

**Table 3-8(b): Class A Equipment Broadcast Information Required**

| Equipage Class | Interactive Aircraft/Vehicles Operational Capabilities | | | | | |
|---|---|---|---|---|---|---|
| | Aid to Visual Acquisition | Conflict Avoidance | Separation Assurance and Sequencing | Flight Path Deconfliction Planning | Simultaneous Approaches | Airport Surface |
| | **Required Transmitted Message Information per Class** | | | | | |
| **A0** **Basic VFR** Aircraft / Ground Vehicles | SV data [Note 2] MS data {Note 3] | SV data [Note 2] MS data {Note 3] | Not Applicable | Not Applicable | Not Applicable | SV data [Note 8] MS data {Note 3] |
| **A1** **Basic IFR** Aircraft [Note 1] | SV data [Note 2] | SV data [Note 2] | Not Applicable | Not Applicable | SV data [Note 2] | SV data [Note 8] |

| | | | | | | |
|---|---|---|---|---|---|---|
| and Ground Vehicles | MS data {Note 4] | MS data {Notes 4, 7] | | | MS data {Notes 4, 7] | MS data {Note 4] |
| **A2** **Enhanced IFR** Aircraft Only | SV data [Note 2]<br><br>MS data {Note 5] | SV data [Note 2]<br><br>MS data {Note 5] | SV data [Note 2]<br><br>MS data {Note 5] | SV data [Note 2]<br><br>MS data {Note 5] | SV data [Note 2]<br><br>MS data {Note 5] | SV data [Note 8]<br><br>MS data {Note 5] |
| **A3** **Extended Capability** Aircraft Only | SV data [Note 2]<br><br>MS data {Note 5]<br><br>OC data [Note 6] | SV data [Note 2]<br><br>MS data {Note 5]<br><br>OC data [Note 6] | SV data [Note 2]<br><br>MS data {Note 5]<br><br>OC data [Note 6] | SV data [Note 2]<br><br>MS data {Note 5]<br><br>OC data [Note 6] | SV data [Note 2]<br><br>MS data {Note 5]<br><br>OC data [Note 6] | SV data [Note 8]<br><br>MS data {Note 5]<br><br>OC data [Note 6] |

*Notes for Table 3-8(b):*

1. *Message content required to support report Element # in Tables 3.4-1, 3.4-2, and 3.4-3. Only the appropriate information ned be broadcast.*
2. *Contents to support SV elements 1 through 15.*
3. *Contents to support MS elements 1 through 4.*
4. *Contents to support MS elements 1 though 6.*
5. *Contents to support MS elements 1 through 11.*
6. *Contents to support OC elements 1 through 5*
7. *Not applicable for ground vehicles.*
8. *Contents to support SV elements 1, 2, 3, 5-8, 10, 14.*

### 3.4.4.2 Broadcast-Only Subsystems (Class B)

As a broadcast-only subsystem no reports are required. Table 3-9 indicates the required information to support users in locating and identifying the transmitting participant. Certification of these classes is required to support the overall quality and safe usage of information used in ADS-B dependent applications.

**Table 3-9): Class B Equipment ADS-B Information Transmission**

| | **User Applications to be Supported** | | |
|---|---|---|---|
| **Equipage Class** | Aid to Visual Acquisition | Conflict Avoidance | Airport Surface |
| | **Required Transmitted Message Information per Class** | | |
| **B1** **Aircraft** Broadcast Only | SV data [Note 2]<br><br>MS data [#1, 3, 4, 6] | SV data [Note 2]<br><br>MS data [#1, 2- 4, 6] | SV data [Note 2]<br><br>MS data [#1, 3, 4, 6] |
| **B2** **Ground Vehicle** Broadcast Only | SV data [Note 2]<br><br>MS data [Note 4] | SV data [Note 2]<br><br>MS data [Note 4] | SV data [Note 2]<br><br>MS data [Note 4] |
| **B3** **Fixed Obstruction** Broadcast Only | SV data [Note 3]<br><br>MS data [Note 4] | SV data [Note 3]<br><br>MS data [Note 4] | SV data [Note 3]<br><br>MS data [Note 4] |

*Notes for Table 3-9:*

1. *Numbers (#) refer to data elements in Tables 3-5, 3-6, and 3-7.*
2. *State Vector elements 1-9, 11, and 14 required.*
3. *State Vector elements 1 through 6 required.*
4. *Mode-status elements 1, 3,4 required.*
5. *On the airport surface, aircraft are not required to report altitude, but must indicate that they are on the surface.*
6. *Ground vehicles are not required to broadcast altitude or altitude rate.*

### 3.4.4.3 Receive-Only Subsystems (Class C)

Table 3-10 defines ADS-B reports required in ground applications.

**Table 10: Class C Equipment ADS-B Report Contents**

| | **Receive-Only Operational Capabilities** | | | | | |
|---|---|---|---|---|---|---|
| **Equipage Class** | Aid to Visual Acquisition | Conflict Avoidance | Separation Assurance and Sequencing | Flight Path Deconfliction Planning | Simultaneous Approaches | Airport Surface |
| | **ADS-B Output Reports Required** | | | | | |
| **C1 ATS En Route and Terminal** | All Elements | All Elements | All Elements | All Elements | Not Applicable | Not Applicable |
| **C2 Approach and Surface** | All Elements | All Elements | All Elements | Not Applicable | All Elements | All Elements |
| **C3 Flight Following** User-Operator Custom Application | All Elements | Not Applicable | All Elements | Not Applicable | Not Applicable | All Elements |

*Note: "All elements" consists of every element of the State Vector, Mode-status, and On-Condition report.*